

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
30 August 2001 (30.08.2001)

PCT

(10) International Publication Number
WO 01/62877 A1

(51) International Patent Classification:
1/02, 10/02

C10L 1/14,

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(21) International Application Number: PCT/GB01/00777

(22) International Filing Date: 23 February 2001 (23.02.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0004522.9 26 February 2000 (26.02.2000) GB
0004519.5 26 February 2000 (26.02.2000) GB

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(81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:

- with international search report
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.



WO 01/62877 A1

(54) Title: FUEL ADDITIVE

(57) Abstract: There is described a fuel additive composition comprising an alkanolamide, an alkoxyated alcohol, an alkoxyated fatty acid, or a derivative thereof, in which the degree of alkoxylation of the C₁₈ to C₂₂ fatty acid is from 0.5 to 5 mols of alkoxyate to 1 mol of fatty acid. There is also described a fuel composition comprising a liquid hydrocarbon fuel and a surfactant composition according to the invention. A method of running an internal combustion engine comprising the use of such a fuel is also described.

FUEL ADDITIVE

This invention relates to novel fuel compositions which comprise novel surfactant compositions and to methods of preparation the fuels compositions and surfactants.

5

International Patent Application No WO 98/17745 describes a surfactant composition which comprises,

10

25% v/v of a diethanolamide,
50% v/v of an ethoxylated alcohol, and
25% v/v of a fourteen carbon chain fatty acid with seven ethoxylate groups.

15

WO '745 especially describes fuel compositions comprising, *inter alia*, an additive made up of a fatty acid diethanolamide, an alcohol ethoxylate and an ethoxylate of a fatty acid, the degree of ethoxylation being selected so that a long term stable fuel composition is formed.

Specifically, WO '745 teaches the use of lauric acid and lauric diethanolamide.

20

Co-pending International Patent Application No WO 99/20715 to Pure Energy Corporation describes similar surfactant compositions in which the fatty acid used has a hydrocarbon chain length of from C₉ to C₁₅.

25

Furthermore, US Patent No 6,017,369 describes a diesel fuel composition comprising, *inter alia*, diesel, ethanol and a fatty acid having a carbon chain length of from C₉ to C₁₅.

30

Whilst such additives provide significant reductions in emissions and may be useable at low concentrations, they suffer from the disadvantage that, for example, lauric acid has a relatively high melting point of between 44 and 46°C. Thus, at room temperature, lauric acid is waxy and difficult to formulate.

We have now surprisingly found a novel surfactant fuel additive which overcomes or mitigates the problems of known prior art composition.

- 5 Thus according to the invention we provide a fuel additive composition comprising an alkanolamide, an alkoxylated alcohol and an alkoxylated C₁₈-C₂₂ fatty acid or a derivative thereof in which the degree of alkoxylation of the fatty acid is from 0.5 to 5 mols of alkoxylate to 1 mol of oleic acid.
- 10 The alkanolamide is preferably an ethanolamide and more preferably a diethanolamide. Especially preferred are the diethanolamides and particularly the super diethanolamides. By the term super diethanolamide we mean a diethanolamide in which the nitrogen is substituted by an alkyl substituent e.g. alkyl C₅ to C₂₀, preferably C₈ to C₁₈, more preferably C₁₀ to C₁₈. The most preferred diethanolamide
- 15 has a C₁₈ alkyl substituent i.e. oleic diethanolamide.

There are three commercial routes to alkanolamides;

Acid + alkanolamine = alkanolamide + water

- 20 Plant or animal oil (triglyceride) + alkanolamine = alkanolamide + glycerol
- Methyl ester + alkanolamine = alkanolamide + methanol

- These are listed in order of increasing product quality. The route via the acid often uses an excess of alkanolamine to produce a product higher in amide than is
- 25 obtainable from the acid if a stoichiometric ratio is used; these products are sometimes referred to as Kritchevsky amides. The products derived from reaction of substantially stoichiometric proportions of an alkanolamide with a fatty acid ester, typically a methyl or glyceryl ester, are referred to as super amides.

- 30 The alkoxylated alcohol is preferably an ethoxylated alcohol. It is essential that the ethoxylated alcohol is an oil soluble alcohol. Therefore, alkanols are preferred and

- these may be primary, secondary or tertiary alkanols and especially primary alkanols. As the oil solubility of the alcohol may vary with the carbon chain length of the ethoxylated alkanol, the alkanol is preferably a C₅ to C₂₂ alkanol, more preferably C₅ to C₁₅ alkanol. The ethoxylated alcohol may comprise a mixture of alkanols.
- 5 However, it is preferred that in such mixtures one alkanol will predominate. Thus, the most preferred alkanol is predominantly a C₉ to C₁₁ alkanol. In addition the degree of ethoxylation of the alcohol may be varied and the oil solubility will, generally, decrease with the increase in the degree of ethoxylation. It is preferred that the ethoxylate to alcohol ratio is greater than 2. More preferably, the ethoxylate to
- 10 alcohol ratio is from between 1 and 10, preferably between 1 and 5, more preferably between 1 and 3 and especially between 2 and 3. A commercially available ethoxylated alcohol is especially preferred in which the ethoxylate to alcohol ratio is 2.75. Such an alcohol ethoxylate is available as NEODOL 91/2.5.
- 15 The fatty acid ethoxylate may comprise the free acid, an ester, a mixture of esters or a mixture of the acid and one or more esters. When a fatty acid ester ethoxylate is used, the ester is preferably an alkyl oleate, preferably a C₁ to C₁₀ alkyl oleate, such as ethyl oleate and especially methyl oleate. The fatty acid derivative is preferentially an ester which may comprise any conventionally known ester moiety, however,
- 20 preferably the ester is an alkyl ester. The alkyl group may be a primary, secondary or tertiary alkyl group. However, the preferred ester group is a straight chain alkyl group, the alkyl chain being from C₁ to C₁₀. The methyl ester is especially preferred.

The fatty acid group may be any known C₁₈ to C₂₂ fatty acid but oleic acid (C₁₈) is

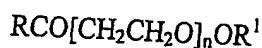
25 preferred.

Alkyl ester fatty acid ethoxylate may be manufactured using conventional methods known *per se*. However, current technology only permits ethoxylation of a fatty acid ester by the PEG/fatty acid route where, in a fatty acid of the general formula

30 RCOOR¹, R¹ is methyl.

We have now found that such ethoxylated fatty acid esters may be manufactured by esterification of a fatty acid with a methoxy polyethylene glycol (PEG) or any other alcohol ethoxylate, for example, a C₉ or C₁₁ alcohol ethoxylate.

- 5 Such novel processes can produce ethoxylated fatty acid esters of the general formula;



I

- 10 wherein R is an alkyl C₈ to C₂₀ group;
R¹ is an alkyl, C₁ to C₁₀; and
n is an integer from 1 to 10.

- 15 Alternatively, ethoxylated fatty acids of formula I may be manufactured by esterification of RCOOH with R¹[OCH₂CH₂]_nOH, wherein R, R¹ and n have the meanings defined above.

However, in addition, the alcohol ethoxylate might be, for example, an alkylphenol ethoxylate.

- 20 The degree of alkoxylation, e.g., ethoxylation, propyloxylation or a mixture thereof, is chosen to optimise performance in the blend with the other two selected surfactants and may be from 0.5 to 5 but more preferably from 0.5 to 2.5. It is especially preferred that the alkoxylation comprises ethoxylation. A suitable product within this
25 range would be, for example that derived from the addition of 1 mol of ethylene oxide to 1 mol of oleic acid, or a derivative thereof.

- 30 The fatty acid ethoxylate, e.g. oleic acid ethoxylate, may be derived from a variety of feedstocks, readily available worldwide. However, in a preferred embodiment of the invention the fatty acid ethoxylate may be produced by ethoxylation or esterification of acids derived from animal fats e.g. beef tallow or vegetable oils, such as soya, etc.

Thus the oleic acid precursor may be predominantly, e.g. from 65-70% v/v, fatty acid, e.g. oleic acid, but may also contain linoleic acid, e.g., 10-12% v/v, and may also include small amounts of stearic, palmitic and/or myristic acids.

- 5 The ratio of the fatty acid alkoxylate, e.g. oleic acid alkoxylate to the alkanolamide may vary slightly, but is preferably 1:1v/v.

The additive of the invention may be added to any known hydrocarbon fuel, e.g. diesel, petrol or alcohol, such as ethanol, which may or may not contain water. The
10 invention is seen to particularly good effect when added to fuels based on low fraction oils.

The preferred additive of this invention is a non-ionic surfactant and preferably a blend of surfactants. It is a preferred feature of this invention that the surfactants be
15 selected by their nature and concentration that the additive (as well as any water or other non-fuel liquid present) be solubilised within the fuel. For this purpose it is convenient to have regard to the hydrophilic-lipophilic balance (HLB) of the surfactant, the value being calculated according to the expression.

20
$$\text{HLB} = \frac{\text{mol. wt of hydrophilic chain} \times 20}{\text{total mol. wt}}$$

The values will depend on the length of the hydrophilic chain, typically an ethoxylate chain. The length of the chain will increase the extent of solubilisation because of a
25 greater ability to solubilise.

As with the compositions described in WO98/17745, a blend of surfactants is preferred, preferably by selecting one appropriate to the fuel.

30 The invention has the ability to unify the HLB requirements of any liquid fuel which in turn allows for one dose to be used in any fuel from C5 carbon chains up. The benefit being the amount of treatment directly related to the co-solvency ability.

Preferably the ethoxylate of the oleic acid makes up about 25% by volume of the additive and further preferably the alcohol ethoxylate comprises 50% by volume of the additive.

5

An additive of the invention may be added to a hydrocarbon fuel, eg diesel, petrol or alcohol, such as ethanol which may or may not be contaminated with water. Alternatively the hydrocarbon fuel may be a blend of a petroleum based fuel such as diesel or petrol, with an alcohol such as ethanol. The invention is seen to particularly
10 good effect when added to synthetic fuels based on low fraction oils.

The hydrocarbon fuel may comprise any known hydrocarbon fuel or mixtures thereof, therefore such fuels include but shall not be limited to diesel, e.g., petroleum diesel, gasoline, aviation fuel, alcohol, etc.

15

In one embodiment of the fuel composition of the invention the hydrocarbon fuel is a petroleum diesel fuel. Such fuels may generally be obtained from the distillation of petroleum and its efficiency can be measured by the cetane number. Suitable diesel fuels for use in accordance with the invention generally have a cetane number of
20 from 35 to 60, preferably from 40 to 50. The amount of diesel fuel blended to form the fuel composition of the invention may be from 60 % v/v to 95 % v/v, based on the total volume of the fuel consumption.

In a further feature of the invention the hydrocarbon fuel, such a diesel or gasoline
25 may include an amount of an oxygenator, e.g. alcohol, an alkanol, such as ethanol. When an alcohol is present the amount of alcohol may vary depending, *inter alia*, upon the nature of the fuel, but may in an amount of from 1 to 50% v/v, preferably 5 to 20% v/v.

30 For fuels, ethanol may be produced from fossil fuel feedstocks or by fermentation of sugars derived from grains or other biomass materials. Therefore, ethanol suitable

- for use in accordance with the fuel compositions of the invention may be fuel grade ethanol derived from yeast or bacterial fermentation of starch-based sugars. Such starch-based sugars may be extracted from corn, sugarcane, tapioca and sugar beet. Alternatively, fuel grade ethanol may be produced via known dilute and/or concentrated acid and/or enzymatic hydrolysis of a particular biomass material, for example, from waste industrial sources including, cellulosic portions of municipal solid waste, waste paper, paper sludge, saw dust. Biomass may also be collected from agricultural residues including, for example, rice husks and paper-mill sludge.
- 10 A suitable fuel grade ethanol for use in accordance with the invention may contain none or only contaminant levels of water. Alternatively, a suitable fuel grade ethanol for use in accordance with the invention may contain higher amounts of water, up to 5% w/w (hydrous ethanol).
- 15 Use of ethanol in combination with a diesel fuel has previously posed problems wherein the ethanol/diesel fuel mixture would undesirably separate into two distinct phases, especially when water is present, and render the resultant mixture unsuitable for use as a combustible fuel. The use of the fuel additives of the invention permits hydrous ethanol to be blended satisfactorily with conventional diesel fuel without forming two phases. The use of fuel grade ethanol blended in accordance with the invention imparts desirable combustion characteristics to the overall fuel composition; such as improved fuel stability, lower smoke and particulate matter, lower CO and NOx emissions, improved antiknock characteristics, and/or improved anti-freeze characteristics.
- 20
- 25 In another aspect the invention provides a fuel composition comprising a light weight fraction and a surfactant fuel additive as hereinbefore described.
- The presence of the additive of the invention ensures that the fuel composition forms a consistent stable homogenous composition and creates a monolayer simultaneously
- 30

a result of which leads to a better more complete burn which reduces pollution and increases miles per gallon.

As a result a blended fuel, particularly alcohol based, is able to combust more
5 precisely with a cooler charge to reduce the iron-formates present from the aldehyde peracids and peroxide reactions normally attributable to engine degradation.

Thus we further provide a fuel composition comprising a fuel and a hydrocarbon fuel additive as herein before described.

10

The concentration of the additive in such fuel compositions can be very low, typically of the order of 0.5 – 50:1000 v/v, preferably from about 1:1000 to 30:1000 v/v and most preferably from 1 to 3:100 v/v. There appears to be no technical or economic benefit in adding more unless a co-solvent dual action is required, when the priority
15 will be dosage against performance. However, the additive to fuel ratio may vary depending upon, *inter alia*, the nature of the fuel. Thus, for example, when the fuel is a hydrous ethanol/diesel blend, the additive to fuel ratio may be as much as 5% v/v, e.g. from 0.1 to 5% v/v, more preferably from 1 to 3% v/v. Alternatively, when the fuel is an anhydrous ethanol/diesel blend the additive to fuel ratio may be as
20 much as 3% v/v, e.g. from 0.1 to 3% v/v. The amount of ethanol present in the diesel/ethanol blends of the invention may be from 5 to 25% v/v, preferably from 7 to 10% v/v and especially 7.7% v/v. When the ethanol in the blend is hydrous ethanol, the amount of water present may be from 4 to 6%v/v based as a percentage of the ethanol.

25

Alternatively, when the fuel is gasoline or a gasoline/ethanol blend, then the additive to fuel ratio may be as much as 5% v/v, from 0.1 to 5% v/v, preferably up to 3% v/v, e.g. 0.1 to 3% v/v, more preferably from 1 to 3% v/v. The amount of ethanol present in the gasoline/ethanol blends of the invention may be from 1 to 25% v/v, preferably
30 5 to 25% v/v, more preferably from 7 to 10% v/v and especially 7.7% v/v. When the fuel is a hydrous ethanol/gasoline blend, the additive to fuel ratio may be as much as

5% v/v. Alternatively, when the fuel is an anhydrous ethanol/gasoline blend the additive to fuel ratio may be as much as 3% v/v.

5 The presence of the additive of the invention ensures that the fuel composition forms a consistent stable homogenous composition and creates a monolayer simultaneously a result of which leads to a better more complete burn which reduces pollution and increases miles per gallon.

10 As a result a blended fuel, particularly alcohol based, is able to combust more precisely with a cooler charge to reduce the iron-formates present from the aldehyde peracids and peroxide reactions normally attributable to engine degradation.

15 We also provide a method of running an engine adapted to use a hydrocarbon or an alcohol based fuel which comprises the use of a fuel composition as hereinbefore described.

20 The use of a fuel additive composition comprising an oleic acid ethoxylate or a derivative thereof is especially advantageous in conjunction with diesel fuel compositions and especially diesel/alcohol compositions. Thus, according to a further feature of the invention we provide a fuel composition comprising a diesel fuel, an alcohol and a surfactant additive as hereinbefore described.

25 The alcohol is preferably ethanol. Optionally, the diesel composition of the invention may additionally include the use of an alkyl ester of oleic acid e.g. an alkyl C1 to 6 alcohol or a long chain fatty alcohol and, optionally a co-solvent of an alkyl alcohol, e.g. a C₃ to C₆ alcohol.

30 According to a further feature of the invention we provide the use of oleic acid or a derivative thereof in the manufacture of a surfactant additive as hereinbefore described.

According to a yet further feature of the invention we provide the use of oleic acid or a derivative thereof in the manufacture of a fuel composition as hereinbefore described.

- 5 The invention will now be described by way of example only.

Example 1

Emission Tests

- 10 Emission tests were carried out on a fuel composition containing the 95% diesel 5% ethanol blend and AAE01.

AAE01 is a surfactant composition comprising 25% v/v of oleic diethanolamide, 50% v/v of NEODOL 91/2.5, and 25% v/v of oleic acid with one molar equivalent
15 ethoxylate groups.

1.1 Test engine

General features of the test engine are given in Table 1.

20

Table 1. General features of the test engine.

Make, model	VOLVO DH10A-285
Number of cylinders and lay-out	6, in-line
Displacement	9.6 dm ³
Injection pump	electrically controlled mechanical in-line pump
Maximum power output	210kW at 2000 1/min
Maximum torque	1200 Nm at 1450 1/min
Compression ratio	20:1
Combustion system	direct injection, turbocharged, intercooled
Emission level	Euro II

1.2 Test equipment and procedures

5 All equipment used for measuring the regulated emissions (Co, Hc, Nox and particulates) conform with the specifications for measurement system given in Annex 4 of ECE Regulation No 49/02.

10 A hydraulic dynamometer by Zollner and a "PUMA Test Assistant" control system by AVL were used for running and controlling the test engine. Regulated gaseous emissions were measured with analysis system by BOO Instrument AB. Particulates were collected using AVL Mini Dilution Tunnel 474. Particulate filters used were Pallflex TXH120WW Ø 70 mm filters.

15 Test procedure was 13 mode test according to ECE Regulation No. 49/02. The maximum power output obtained with each fuel was used to set dynamometer load setting.

The tests were carried out at normal test temperature.

20 FTIR measurement, formaldehyde from heavy-duty engine

In the heavy-duty engine tests, a number of unregulated compounds, including formaldehyde, were measured using a Fourier Transformation Infra-Red (FTIR) system (SESAM II Fast, manufactured by Siemens AG, FRG). More than 20 exhaust
25 components can be measured with this system at a one second time interval.

1.3 Test results

30 The maximum power obtained with D1 fuel was 210 kW at 2000 rpm and maximum torque 1200 Nm at 1450 rpm. Power loss with fuel D2 was below 1%

when compared to D1 fuel. Power losses with fuels D3 and D4 when compared to D1 fuel were 5 and 7% respectively.

Results of the emission tests according to the ECE R49 13-mode test for heavy-duty tests are given in Table 2. One test with each fuel was carried out.

Increase in HC emission was observed for fuels D3 and D4 when compared to fuel D1.

NO_x emission seemed to be slightly lower with fuels D2, D3 and D4 than with fuel D1. However, the change lower than 5% cannot be regarded as very significant due to uncertainty of the measurement method.

Particulate matter emission was about 11% lower with D2 fuel than with D1 fuel. D3 fuel resulted 20% and D4 fuel 27% lower particulate emission than D1 fuel. Also black smoke (Bosch smoke) seemed to be lower with fuels D2, D3 and D4 when compared to D1 fuel.

Table 2. Results of the emissions tests according to ECE R49 test procedure with the VOLVO DH10A-285 engine

Fuel	CO (g/kWh)	HC (g/kWh)	NO _x (g/kWh)	Particulates (g/kWh)	CO ₂ (g/kWh)	Fuel cons. (g/kWh)	Bosch smoke*
D1 (Base)	0.51	0.15	6.3	0.105	688	230	0.50
D2 (Base + 2% AAE01)	0.51	0.15	6.2	0.093	693	231	0.48
D3 (Base + 2% AAE01 + 2% H ₂ O)	0.51	0.20	6.1	0.084	696	233	0.41
D4 (Base + 1% AAE01 + 5% MTBE)	0.51	0.20	6.0	0.076	698	235	0.40

* average value without weighting factors

The results of FTIR measurements are shown in Table 3. The most components measured from the exhaust gases of Volvo DH10A-285 engine were below the detection limit of FTIR equipment. Formaldehyde emission seemed to be slightly higher with D3 fuel than with D2 fuel. The difference resulted from the high load modes 6 and 8. The emission of n-octane was higher with D3 fuel than with D2 fuel, which is in accordance with the results of regulated emissions shown in Table 2.

10

Table 3. Results of the FTIR measurements from ECE R49 test with the VOLVO DH10A-285 engine.

Fuel	N ₂ O (mg/kWh)	NH ₃ (mg/kWh)	CH ₂ O (mg/kWh)	CH ₄ (mg/kWh)	BNZ (mg/kWh)	NC ₈ (mg/kWh)
D2	bd	bd	24	bd	bd	97
D3	bd	bd	35	BD	BD	120

bd = below detection limited

15 Example 2

Light-duty emission tests

2.1 Test vehicle

20 The general features of the petrol fuelled vehicle that was used in the emission tests are shown in Table 4.

Table 4. General features of the test vehicle

25

Make, model	Ford Mondeo 1.6 BFP/270
Model year	1998

Odometer reading	29 100 km
Transmission	manual, 5
Number of cylinders and lay-out	4
Displacement	1.6dm ³
Maximum power output	66 kW

The absolute emission level obtained with FTIR equipment may vary significantly from the level obtained with traditional measurement technologies. However, FTIR technology can be used for comparison of the results with different fuels. Due to very low level hydrocarbon emissions from diesel engines, the most compounds that can be measured with FTIR equipment are below the detection limit. When diesel engines are considered, FTIR is most suitable to monitor the formaldehyde emission. Examples of the compounds that were recorded during these measurements were as follows:

- formaldehyde (CH₂O)
- nitrogen dioxide (NO₂)
- nitrous oxide (N₂O)
- ammonium (NH₃)
- methane (CH₄)
- ethyne (C₂H₂)
- ethene (C₂H₄)
- propene (C₃H₆)
- benzene (BNZ)
- n-octane (C₈H₁₈)
- 1,3-butadiene (C₄H₆)

Test equipment and procedures

All equipment used for exhaust dilution and collection, as well as concentration analysis of the gaseous regulated emissions, conform with the specifications of the Amendment 91/441/EEC of Directive 70/220/EEC.

- 5 A DC type chassis dynamometer manufactured by Froude Consine and an emission measurement system by Pierburg GmbH (FRG) were used.

Tests were conducted at normal test temperature (+23°C). The vehicle was preconditioned with running three times the EUDC part of the test, and soaked at the
10 test temperature for 12 to 16 hours before the test.

The chassis dynamometer settings used for vehicle are presented in Table 5.

Table 5. Chassis dynamometer settings

Inertia	1360 kg
F ₀	7
F ₁	0
F ₂	0.046

15

The gaseous regulated emissions were divided into three sub-cycles. The first part included the first two individual sub-cycles of urban cycle, ECE15 (marked as Phase 1), the second phase was the rest of the ECE15 cycle (marked as Phase 2), and the third part was the extra urban portion (marked as Phase 3) of the current European
20 test cycle (marked as 91/441/EEC).

The results of the test were compared by Sekab with results obtained from similar tests carried out by a AB Svensk Biprovnig Motocenter (Swedish Engine and MOT test centre) on several fuel compositions including Swedish M1 diesel, generally
25 regarded as the cleanest diesel available in Europe.

The comparisons shown on the *Bi07/Ethanol/Diesel Emission Test Results* are evidence to a dramatic reduction in all measured emissions including, -20% CO₂, -30%NO_x and -70% particulates.

- 5 Five months after the original tests VTT took the sample of fuel they had been keeping and ran a cetane test on it, the result of which is enclosed. As noted in this test the sample had remained clear and stable for this period and no deterioration was evident.

10 Results

AAE01/Ethanol/Diesel Blends

Emission Test Results

	CO	HC	Nox	CO2	Particulates
	g/kWh	g/kWh	g/kWh	g/kWh	g/kWh
Mk1	0.61	0.47	6.95	1085	0.2
Mk2	0.61	0.5	7.14	1053	0.21
RME	0.49	0.09	8.99	1053	0.21
Mk1 +5%RME	0.62	0.44	7.16	1054	0.2
Mk2 +30%RME	0.58	0.33	7.8	1068	0.19
AAE01 Diesohol	0.55	0.21	4.9	863.6	0.056

15

AAE01 diesohol compared with Mk1 diesel

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	CO	HC	Nox	CO2	Particulates
	g/kWh	g/kWh	g/kWh	g/kWh	g/kWh
Mk1 Diesel	0.61	0.47	6.95	1085	0.2

AAE01 Diesohol	0.55	0.21	4.9	863.6	0.056
Reductions	10%	55%	29%	20%	72%

Fuel Specifications

- Mk1 - Scandinavian environmental class 1 diesel fuel
- 5 Mk2 - Scandinavian environmental class 2 diesel fuel
- RME - Rapeseed Methyl Ester
- AAE01 - 4.25-94.5% Mk1 diesel + 5% Ethanol (90% grade) + 0.5-0.75% AAE01 (all
% by volume)
- 10 All testing carried out on a Volvo Euro II low emission engine.

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CLAIMS

1. A fuel additive composition comprising an alkanolamide, an alkoxylated alcohol, an alkoxylated C₁₈ to C₂₂ fatty acid, or a derivative thereof, in which the
5 degree of alkoxylation of the fatty acid is from 0.5 to 5 mols of alkoxylate to 1 mol of fatty acid.
2. A fuel additive composition according to Claim 1 characterised in that the alkanolamide is an ethanolamide
10
3. A fuel additive composition according to Claim 3 characterised in that the alkanolamide is a diethanolamide.
4. A fuel additive composition according to Claim 3 characterised in that the
15 diethanolamides are super diethanolamides.
5. A fuel additive composition according to Claim 3 characterised in that the nitrogen in the diethanolamide is substituted by an alkyl C₅ to C₂₀ substituent.
- 20 6. A fuel additive composition according to Claim 5 characterised in that the diethanolamide is substituted by an alkyl C₈ to C₁₈ substituent.
7. A fuel additive composition according to Claim 6 characterised in that the diethanolamide is substituted by an alkyl C₁₀ to C₁₈ substituent.
25
8. A fuel additive composition according to Claim 7 characterised in that the diethanolamide is oleic diethanolamide.
9. A fuel additive composition according to Claim 1 characterised in that the
30 alkoxylated alcohol is an ethoxylated alcohol.

10. A fuel additive composition according to Claim 9 characterised in that the ethoxylated alcohol is an oil soluble alcohol.
11. A fuel additive composition according to Claim 9 characterised in that the
5 ethoxylated alcohol is an alkanol.
12. A fuel additive composition according to Claim 11 characterised in that the ethoxylated alcohol is a primary alkanol.
- 10 13. A fuel additive composition according to Claim 11 characterised in that the alkanol is C₅ to C₂₂ alkanol.
14. A fuel additive composition according to Claim 11 characterised in that the ethoxylated alcohol comprises a mixture of alkanols in which one alkanol
15 predominates.
15. A fuel additive composition according to Claim 11 characterised in that the predominant alkanol is a C₉ to C₁₁ alkanol.
- 20 16. A fuel additive composition according to Claim 9 characterised in that the ethoxylate to alcohol ratio is from between 1 and 10.
17. A fuel additive composition according to Claim 16 characterised in that the ethoxylate to alcohol ratio is from between 1 and 5.
- 25 18. A fuel additive composition according to Claim 17 characterised in that the ethoxylate to alcohol ratio is from between 2 and 3.
19. A fuel additive composition according to Claim 18 characterised in that the
30 ethoxylate to alcohol ratio is 2.75.

20. A fuel additive composition according to Claim 19 characterised in that the ethoxylated alcohol is NEODOL 91/2.5.
21. A fuel additive composition according to Claim 1 characterised in that the fatty acid derivative is present as the free acid.
22. A fuel additive composition according to Claim 1 characterised in that the fatty acid is present as oleic acid, or a derivative thereof.
23. A fuel additive composition according to Claim 22 characterised in that the oleate is an alkyl oleate.
24. A fuel additive composition according to Claim 23 characterised in that the oleate is an alkyl oleate.
25. A fuel additive composition according to claim 1 characterised in that the degree of alkoxylation is 1.
26. A fuel additive composition according to Claim 1 characterised in that the composition comprises 25% v/v of the oleic acid ethoxylate or a derivative thereof.
27. A fuel additive composition according to Claim 1 characterised in that the composition comprises 50% v/v of the alcohol ethoxylate.
28. A fuel composition comprising a liquid hydrocarbon fuel and a fuel additive composition according to claim 1.
29. A fuel composition according to Claim 28 characterised in that the fuel is a diesel fuel.

30. A fuel composition according to claim 29 characterised in that the fuel is a mixture of diesel and an alcohol.

31. A fuel composition according to Claim 30 characterised in that the alcohol is
5 ethanol.

32. A fuel composition according to claim 28 characterised in that the fuel additive to fuel ratio is from 0.5 – 50:1000 v/v.

10 33. A fuel composition according to claim 32 characterised in that the fuel additive to fuel ratio is from 1:1000 to 30:1000 v/v

34. A fuel composition according to claim 33 characterised in that the fuel additive to fuel ratio is from 1 to 3:100 v/v.

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35. A fuel composition according to claim 31 characterised in that the fuel is a hydrous ethanol/ diesel blend.

36. A fuel composition according to claim 35 characterised in that the additive to
20 fuel ratio is up to 5% v/v.

37. A fuel composition according to claim 31 characterised in that the fuel is an anhydrous ethanol/diesel blend.

25 38. A fuel composition according to claim 37 characterised in that the additive to fuel ratio is up to 3% v/v.

39. A fuel composition according to claim 28 characterised in that the fuel is gasoline.

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40. A fuel composition according to either of claim 39 characterised in that the fuel is gasoline/ethanol blend.
41. A fuel composition according to claim 39 characterised in that the additive to
5 fuel ratio is up to 5% v/v.
42. A method of running an internal combustion engine comprising the use of a fuel according to claim 28.
- 10 43. The use of a C₁₈ to C₂₂ fatty acid, or a derivative thereof, in the manufacture of a fuel additive composition according to claim 1.
44. The use according to claim 43 characterised in that the C₁₈ to C₂₂ fatty acid is oleic acid, or a derivative thereof.
- 15 45. The use of a C₁₈ to C₂₂ fatty acid, or a derivative thereof, in the manufacture of a fuel composition according to claim 28.
- 20 46. The use according to claim 45 characterised in that the C₁₈ to C₂₂ fatty acid is oleic acid, or a derivative thereof.
47. A fuel additive or a fuel composition substantially as described in the
25 accompanying examples.
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INTERNATIONAL SEARCH REPORT

International Application No.

PCT/GB 01/00777

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 C10L1/14 C10L1/02 C10L10/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 C10L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 217 229 A (UNIV CITY ; ENERSOLVE CHEMICAL COMPANY LIM (GB)) 25 October 1989 (1989-10-25)	1-3, 5-18, 21, 28-32, 35, 36, 42-46 23, 26, 47
Y	page 3	
P, X	WO 00 36055 A (WILLIAMSON IAN VERNON ; AAE HOLDINGS PLC (GB); HAZEL CLIFFORD JAMES) 22 June 2000 (2000-06-22)	1-7, 9-21, 27-33, 35-43, 45 23, 26, 47
P, Y	page 5 -page 7; claims 16-20 --- -/--	

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

13 July 2001

Date of mailing of the international search report

23/07/2001

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INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 01/00777

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 99 44732 A (KELLY ELIZABETH MARY TERESA ;CLOHESSY JUSTIN PETER (ZA); LUNDIN IN) 10 September 1999 (1999-09-10) page 1 -page 2; claims 12,13,31-33 ----	1-3, 5-18,21, 22, 28-30, 42-47
A	WO 98 17745 A (WILLIAMSON IAN VERNON ;HAZEL CLIFFORD JAMES (GB)) 30 April 1998 (1998-04-30) cited in the application page 4 ----	1-47
A	US 6 017 369 A (AHMED IRSHAD) 25 January 2000 (2000-01-25) cited in the application ----	
A	EP 0 012 292 A (BAYER AG) 25 June 1980 (1980-06-25) ----	
A	WO 99 52994 A (THORLEY DAVID ;STREET PETER (GB); COVAL TECHNOLOGIES LIMITED (GB)) 21 October 1999 (1999-10-21) ----	
A	WO 99 20715 A (PURE ENERGY CORP) 29 April 1999 (1999-04-29) cited in the application ----	
A	WO 98 56878 A (CRAIG DONALD MURRAY ;SMITH STUART D B (CA); KLAUSMEIER WILLIAM HIL) 17 December 1998 (1998-12-17) -----	

INTERNATIONAL SEARCH REPORT
Information on patent family members

International Application No.
PCT/GB 01/00777

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 2217229 A	25-10-1989	NONE	
WO 0036055 A	22-06-2000	AU 1788500 A	03-07-2000
WO 9944732 A	10-09-1999	AU 2941799 A	20-09-1999
WO 9817745 A	30-04-1998	AU 4710097 A	15-05-1998
		BR 9711430 A	31-10-2000
		DE 19782068 T	11-11-1999
		GB 2334964 A,B	08-09-1999
		JP 2001502374 T	20-02-2001
		SE 9901364 A	16-04-1999
US 6017369 A	25-01-2000	AU 1741100 A	13-06-2000
		FI 20011065 A	21-05-2001
		WO 0031216 A	02-06-2000
		US 6190427 B	20-02-2001
		US 2001003881 A	21-06-2001
EP 0012292 A	25-06-1980	DE 2854437 A	26-06-1980
		AT 589 T	15-02-1982
		AU 5392679 A	19-06-1980
		BR 7908184 A	22-07-1980
		CA 1137314 A	14-12-1982
		DD 147683 A	15-04-1981
		DE 2961910 D	04-03-1982
		IE 49236 B	04-09-1985
		JP 55082190 A	20-06-1980
		US 4295859 A	20-10-1981
		ZA 7906800 A	31-12-1980
WO 9952994 A	21-10-1999	GB 2336120 A	13-10-1999
		AU 3430599 A	01-11-1999
		EP 1095121 A	02-05-2001
WO 9920715 A	29-04-1999	US 6074445 A	13-06-2000
		AU 731702 B	05-04-2001
		AU 9809798 A	10-05-1999
		EP 1027410 A	16-08-2000
		NO 20001972 A	08-06-2000
		US 6183524 B	06-02-2001
		US 2001005956 A	05-07-2001
		ZA 9809525 A	20-04-1999
WO 9856878 A	17-12-1998	AU 7755098 A	30-12-1998